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Modeling Human Circulation in the Minoan Palace at Malia

Abstract: This paper presents an innovative methodology based on cost analyses used to quantify human circulation and spatial configuration within the Neopalatial[1] Palace at Malia, Crete. The study focuses on the Late Minoan I architectural phases of the Palace and assesses the effects of the second phase modifications on the circulation. It can be shown that during the first phase, circulation was less restricted than during the second phase. The second phase modifications altered the west entrance system and complicated the circulation pattern within the West Wing of the palace drastically.

Introduction

The "simple" architectural plans of ancient buildings and cities have become a rich source of information as archaeologists become acquainted with the new tools used for the quantification of spatial configurations (e.g. Space Syntax). Yet, surprisingly, one of the most important criteria concerning human movement, Euclidean distance, has frequently been overlooked in research. The incentive for the present study is to synthesize a methodology where Euclidean distance is taken as the criterion to quantify spatial configuration in an ancient built environment. The methodology presented here will possibly find a broad range of future applications in archaeological research and complement current methodologies of design analyses on ancient architecture in a rewarding manner.

The study has two principal aims: 1) to synthesize a methodology based on Euclidean distance and cost analyses[2] that can be used to quantify the human circulation and spatial configuration within an ancient built environment 2) to apply the methodology to the two architectural phases of the Neopalatial Minoan Palace at Malia in order to study the architectural design and accessibility patterns of the building. ArcView 9.2 (© ESRI) is used as the GIS software.

Overview: the Minoan Palace at Malia

The archaeological site of Malia is located on the central north coast of the Mediterranean island, Crete. The Neopalatial Palace covers approximately 8,462 m^2 at ground floor level. It is a grand building standing amid urban quarters comprised of private houses, workshops and public spaces. There are ample traces that the Palace building carried more than one storey but not enough archaeological evidence exists to infer what these upper storeys really looked like. After an earlier, Middle Bronze Age phase, of which little survives, after destruction by fire, the Palace was reconstructed in the mature Late Minoan (LM) IA[3]. This mature LM IA phase of the Palace is visible on the site today and is what we have referred to as the "first phase". A series of repairs and modifications that came about in the mature LM IA or LM IB period, are referred here to as the "second phase". The modifications mostly comprise mud brick walls which were used as barriers and were erected in some parts of the Palace, particularly in the West Wing.

During the Neopalatial period, the Palace had five entrances: to the north, northeast, southeast, south and west *(Fig. 1)*. The central court, "the diagnostic feature of a Minoan Palace,"[4] covers about 1,090 m^2 of the ground floor plan. This court must have provided light and air to the rooms surrounding it both at ground floor level and upper storey, dividing and uniting parts of the Palace[5], enriching possibilities of circulation with the large open space it provides[6] and

[1] The Neopalatial period covers the Middle Minoan III (ca. 1700/1650–1600 BCE), Late Minoan IA (ca. 1600/1580–1480 BCE) and Late Minoan IB (ca. 1480–1425 BCE) pottery phases (traditional chronology).

[2] For more information on GIS-based cost surface analyses see Kvamme 1999, 175–176; van Leusen 2002, 4–9; Wheatley / Gillings 2002, 151–159.

[3] Driessen / MacDonald 1997, 182.

[4] Davis 1987, 161.

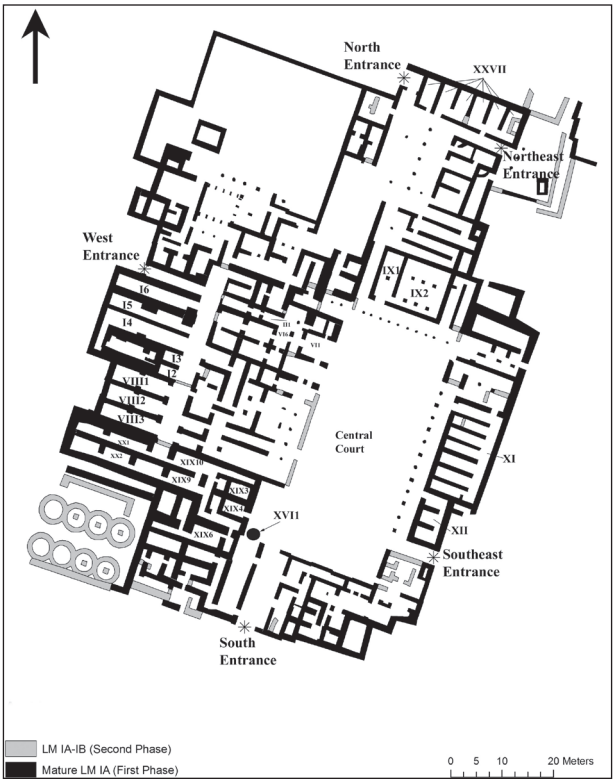

Fig. 1. Parts of the Palace referred in the text.

forming the focus of many daily and/or ceremonial activities. The building incorporates two other courts to the north and northwest and other courts are located outside of the Palace both to the east and to the west. The one to the west is crossed by a finely paved, probably ceremonial, walkway leading to the north entrance of the Palace.

The northwest quarter of the Palace has been interpreted as the "residential quarter" by some scholars implying the existence of a royal family residing in the Palace. However, neither the finds uncovered from this area nor the architecture itself, really indicate that this part of the Palace was used as a living quarter while the architectural elaboration could point to a ceremonial function[7]. The room to the immediate north of the Central Court, the so-called "pillar hall" (IX2), contains six pillar bases in two rows that are preceded by a possible ante-room with a single pillar base (IX1). It has been suggested that this hall carried a large ceremonial/banqueting hall on the second floor, the columns of which were supported by the pillars on the ground floor[8]. Some scholars associated this second storey banqueting hall with the North Court of the Palace and the nearby rooms, which may have been primarily related to the preparation and storage of the food consumed in the banqueting hall[9].

The amount of area devoted to food storage on ground level of the Malia Palace in particular and of all Minoan Palaces in general is remarkable. At Malia, the food storage area comprises about 4–5 % of the ground floor of the Palace. Most of the East Wing (XI and XII) and part of the West Wing (I2–6 and VIII1–3) is taken up by a system of elongated, rectangular storage rooms covering around 153 and 221 m^2 respectively. Although there is good archaeological evidence referring to the storage function of these rooms in the East and West Wings, the storage function of the silo-like circular structures outside to the southwest and the room cluster in the north part (XXVII) of the Palace remain open to discussion.

The Minoan Palaces certainly played a crucial role in the Minoan cult. It is probable that the "altar" in the centre of the Central Court and the "kernos" – a circular stone with a series of depressions – in the southwest corner (XVI1) of the Central Court together with a series of rooms in the east part of the West Wing were used for ritual or general ceremonial activity.

Methodology

The "Cost Distance Tool" in the ArcGIS Spatial Analyst toolbox is used for the analyses in this study. To model the Palace walls as obstacles for the circulation, an input cost raster is created where the cells denoting the walls of the Palace are assigned a "NoData"[10] value.

To create the input cost raster, first the architectural remains are digitized in ArcMap. Two colors, produced with the RGB color model, are used to symbolize the walls that belong to the first and sec-

[5] Graham 1962, 73.

[6] Palyvou 2002, 173.

[7] Nordfeldt 1987, 187.

[8] Graham 1962, 45.

[9] Graham 1962, 136–137.

[10] "Cell values can be either positive or negative, integer, or floating point. Cells can also have a NoData value to represent the absence of data." For further explanation on the NoData concept in ArcGIS 9.2, see the "ArcGIS 9.2 Desktop Help" web site at webhelp.esri.com/arcgisdesktop/9.2/index.cfm?TopicName=welcome.

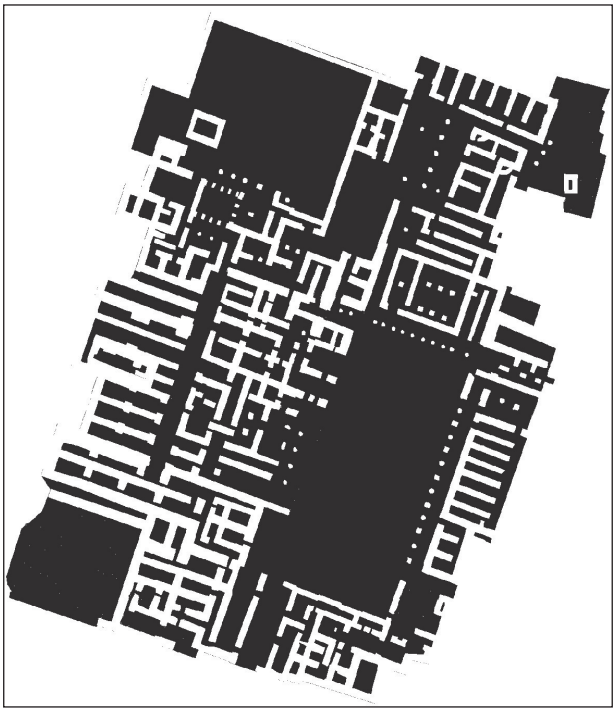

Fig. 2. Input cost raster created to conduct cost analyses in the first phase of the Palace.

ond phases of the Palace. In an RGB color model the color value for each of the three main colors (i.e. red, green and blue) ranges from 0 to 255. A purple color with a red value of 150 is picked for the first phase remains and a blackish color with a red value of 30, for the second phase modifications. The third color on the map is white, the default background color of ArcMap that has a red value of 255. First, the plan is exported from ArcMap as a high-resolution jpeg image, then added as a "raster dataset" layer on the former map in ArcMap and finally, geo-referenced. The "Reclassify" tool of the Spatial Analyst toolbox is used to reclassify the cells within this raster dataset according to their red values. Ideally, all the cells in the raster dataset have received one of the three red values of purple, blackish and white color (i.e. 30, 150 and 255). However, the red values of some of the cells have deviated from the ideal value due to the image exportation and importation processes. As a result, not all cells in the raster dataset have one of the three red values of the purple, blackish and white colors; instead, the red values of the cells have accumulated around these three values. In order to bypass this complication, the red values of the cells have to be reclassified into three groups: 0–55, 55–200 and 200–255. These groups represent the second phase modifications, first phase remains and empty space (i.e. the space available for circulation) respectively.

For analyzing the circulation in the first phase, the cells representing the first phase walls are assigned a "NoData" value as the new reclassification value. The rest of the raster dataset cells, representing the second phase modifications and the empty space, are assigned a value of 1, meaning that neither the empty space nor the modification walls of the second phase should be considered as obstacles for circulation during the analyses *(Fig. 2)*. Likewise, for analyzing how the second phase modifications affected the circulation, cells representing both the first and second phase walls are assigned a "NoData" value, and only the cells representing the empty space are assigned a value of 1.

Analyses and Results

For the first phase of the Palace, the accessibility patterns provided by the south, southeast and north-northeast entrance systems are similar to each other *(Fig. 3a–d)*. Exceptions are the east storage rooms, "pillar hall" and part of the northwest court which are closer to the southeast entrance than to the south entrance. The west entrance system shows unique characteristics as it is the single entrance at the western side of the building providing an "architectural permeability" towards the inner space, due to the east-west orientation of the walls in the West Wing *(Fig. 3e)*.

There is disagreement among some scholars on the existence of a West entrance during Minoan times. It is suggested that the entrance was created by the people looting the ruins of the Palace in modern times[11]. Note that, if the west entrance did not exist, almost the entire West Wing would become quite remote (with a Euclidean distance range from 45 to 85 meters) to any entrance of the Palace *(Fig. 3f)*. In this case, stacking the storage rooms at the West Wing with agricultural goods would be extremely difficult and unfeasible since one would have to transport loads for at least. 80 m from one of the other four entrances. The location of the west entrance might be part of the original design of the Palace or a later addition as necessity arose. It is, however, highly unlikely that the west entrance, providing an effective penetration towards the Central Court and located at one of the most inaccessible

[11] See VAN EFFENTERRE 1987 with comments by Pelon.

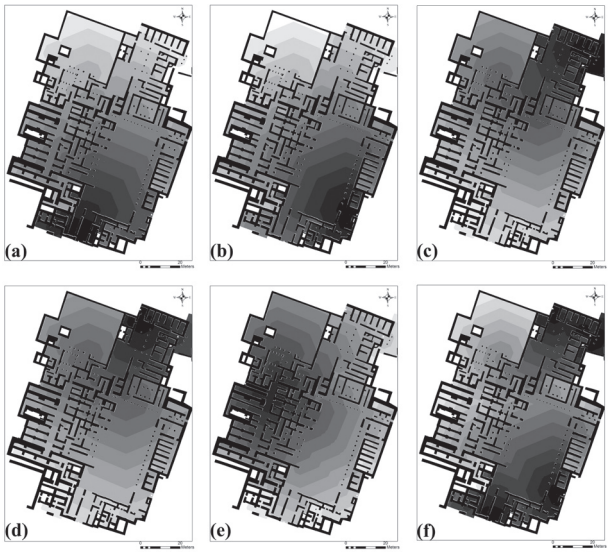

Fig. 3.(a–e) Accessibility patterns provided by the south, southeast, north, northeast and west entrance systems respectively. (f) Accessibility pattern provided by the four entrance systems, leaving the west entrance system out. As the color gets lighter, the distance increases.

points to all the other four entrances of the Palace, was a coincidental looting opening. Moreover, the same area already carried an entrance in the Middle Bronze Age.

Note that the most inaccessible part of the Palace in the first phase is the cluster of rooms to the southwest of the Central Court (XIX3, 4, 6, 9, 10 and XX1, 2), the storage rooms in the East Wing, the "pillar hall" and the area to the north of the "residential quarter." Three of the five entrances (west, southeast and north) serve as the nearest entrance to almost 85% of the space enclosed by the Palace. While the spaces that are served by the south and northeast entrances are notably small *(Fig. 4a)*. One wonders what the was rationale to establish these two entrances as they seem to be "useless" in the first phase of the Palace if one solely considers their spatial assets.

To answer this question, one has to move off the "spatial performance" of the Palace entrances and examine the archaeological evidence to elucidate their "cultural performance". The north entrance of the Palace at Malia is constructed with a large serpentine door jamb base and a double system of massive thresholds[12]. As stated above, a finely paved walkway crossing the West Court turns to the left at the northwest corner of the Palace and leads to this north entrance. With these distinctive architectural features in mind, it can be suggested that the major and ceremonial entrance of the Palace was indeed the north entrance[13]. The south entrance was also finely built with a wide and paved passageway/anteroom leading to the south edge of the courtyard. What is notable is that the "kernos" (see above) is located to the southwest of the Central Court within the area allocated to the south entrance. It is possible that people using the south entrance were associated with the ceremonies taking place in the Central Court as spectators and/or participants and used the "kernos" for placing their offerings just before entering the courtyard. If the above interpretations are correct, the northeast entrance may then be considered as a "daily entrance," serving the possible workshops, storerooms and/or kitchens in the northern part of the Palace. Similarly, the southeast entrance, the closest entrance to the spatially isolated storerooms in the East Wing, may have served to access the storerooms in this East Wing.

During the second phase of the Palace, the cluster of rooms to the southwest of the Central Court becomes completely inaccessible, at least at ground floor level. The architectural modifications do not alter the accessibility provided by the north, northeast, south and southeast entrance systems much. Note, however, that the West Wing of the Palace becomes more distant to the north and northeast entrances and the northwest part of the Palace becomes more distant to the south and southeast entrances. With the modifications of the second phase the function of the west entrance system changes significantly. The entrance becomes more distant to the south rooms of the western storage area (VIII)[14], the rooms to the northeast of the West Wing that were associ-

Fig. 4. Spaces allocated to the entrances according to their proximity. (a) First phase. (b) Second phase.

[12] Driessen 1995, 74 .

[13] Driessen 1995, 74.

ated with religious activity (II1 and VI)[15] and the so-called "residential quarter" in the northwest area of the Palace. The shortest path analysis illustrates that the accessibility patterns in the West Wing become highly complicated due to the modifications of the second phase. Note also that in the second phase, the west entrance is the closest entrance for a very small area enclosed by the Palace walls whereas in the first phase the entrance served almost the entire western half of the Palace. The result illustrates to what extent the accessibility provided by the west entrance system became restricted in the second phase *(Fig. 4b)*. The areas served by the west entrance in the first phase in the northeast area of the West Wing and in the northwest area are taken over by the southeast and the north entrances respectively.

Note that apart from walls, Palace doors and guards would undoubtedly affect accessibility patterns and hence, the results of this study. In Malia archaeological evidence points to the existence of wooden doors[16] though the information is too scanty to incorporate into this study.

Conclusions

The GIS-based methodology presented in this study not only provides archaeologists with an innovative method to quantify human circulation and spatial configuration within an ancient built environment but it also forms a complementary methodology for the current trends in the research regarding the design of ancient built environment, which is dominated by Space Syntax techniques[17]. The power of GIS as a tool for spatial quantification is verified once more with the innovative and exemplary approach presented in this study. The advanced algorithms on which the cost analysis is based and effective maps used to illustrate the results in ArcView have created a means to efficiently quantify the spatial configuration and circulation pattern in the Minoan Palace at Malia within the mature LM IA and LM IA-IB periods. As illustrated by this study, current GIS technologies are advanced and flexible to such a degree that they can be manipulated to work on inquiries unique to archaeological research and archaeologists do not have to limit the contents of their research according to the GIS tools that seem to be available in a GIS package at first glance.

This study has demonstrated that the architectural modifications in the LM IA-IB phase of the Palace at Malia changed the human circulation in the West Wing drastically and restricted the easy accessibility provided by the west entrance system in the mature LM IA phase. After the analyses conducted in this study it can be suggested that, during the LM IA-IB period, the Palace was under the control of an individual or a group of individuals who intentionally reorganized the circulation of the West Wing of the Palace and tried to impose a passive control over the people using the west entrance. The restrictions created an architectural complexity, indeed a labyrinth, in the West Wing of the Palace that would "target" the people who had been left out of the decision making processes of the architectural modifications and left unacquainted with the end result. Hence, it is likely that the restrictions sharpened the feeling of being an "outsider" to the Palace and turned the building into a more secluded place for those who had the control over the architecture (and the resources therein). Note that the LM IA-IB modifications in the Palace of Malia are part of a possible architectural trend in Minoan architecture restricting the accessibility within the different monumental buildings[18]. Further analysis concerning the architecture of the mature LM I period will increase our knowledge on the character of these contemporary modifications, and contribute to the discussions concerning increased inequality and insecurity within Minoan society[19], exclusion of the public from elite affairs[20] and the socio-economic crises the Minoans might have been facing following the Theran Erup-

[14] The rooms to the north of the western storage magazines that can still be reached easily after the modifications (I2–6) were found mostly empty during the excavations. See Driessen / MacDonald 1997, 184.

[15] See Pelon 1992, 78.

[16] See Shaw 1971, 29, 151.

[17] See http://www.spacesyntax.org. See also Letesson 2007 for Space Syntax applications on Minoan architecture.

[18] Driessen 1995, 85.

[19] Driessen/MacDonald 1997, 46.

[20] Driessen 1995, 67.

[21] an overview of the archaeological evidence suggesting a severe economic dislocation in Bronze Age Crete triggered by the Theran Eruption and gradually building up in the mature LM I, see Driessen / MacDonald 1997.

tion (ca. 1550–1530 BCE)[21] within this dynamic period of Minoan history.

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References

Davis 1987
E. Davis, The Knossos Miniature Frescoes and the Function of the Central Courts. In: R. Hägg / N. Marinatos (eds.), The Function of the Minoan Palaces (Stockholm 1987) 157–161.

Driessen 1995
J. Driessen, Some Observations on the Modification of the Access Systems of Minoan Palaces. Aegean Archaeology 2, 1995, 67–85.

Driessen / MacDonald 1997
J. Driessen / C. MacDonald, The Troubled Island: Minoan Crete before and after the Santorini Eruption. Aegaeum 17 (Liège 1997).

Graham 1962
J. Graham, The Palaces of Crete (Princeton 1962).

Kvamme 1999
K. Kvamme, Recent directions and developments in geographical information systems. Journal of Archaeological Research 7:2, 1999, 153–201.

Letesson 2007
Q. Letesson, Du phénotype au génotype. Analyse de la syntaxe spatiale en architecture minoenne (MM IIIB-MR IB). Unpublished PhD Thesis (Louvain-la-Neuve 2007).

Nordfeldt 1987
A. Nordfeldt, Residential quarters and lustral basins. In: R. Hägg / N. Marinatos (eds.), The Function of the Minoan Palaces (Stockholm 1987) 187–194.

Palyvou 2002
C. Palyvou, Central courts: The supremacy of the Void. In: J. Driessen / I. Schoep / R. Laffineur (eds.), Monuments of Minos: Rethinking the Minoan Palaces. Aegaeum 23 (Liège 2002) 167–177.

Pelon 1992
O. Pelon, Guide de Mallia. Le palais et la nécropole de Chrysolakkos (Paris 1992).

Shaw 1971
J. Shaw, Minoan architecture: Materials and Techniques. ASAtene 49 (Rome 1971).

Van Effenterre 1987
H. Van Effenterre, The function of Monumentality in the Minoan Palaces. In: R. Hägg / N. Marinatos (eds.), The Function of the Minoan Palaces (Stockholm 1987) 85–87.

van Leusen 2002
P. M. van Leusen, Line-of-Sight and Cost Surface Analysis Using GIS. In: P. M. van Leusen, Pattern to Process: Methodological Investigations into the Formation and Interpretation of Spatial Patterns in Archaeological Landscapes (Groningen 2002) Chapter 6. http://irs.ub.rug.nl/ppn/239009177 [10 Sep 2006].

Wheatley / Gillings 2002
D. Wheatley / M. Gillings, Spatial Technology and Archaeology: the Archaeological Applications of GIS (London 2002).

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